ADIABATIC SHEAR BANDS IN THE TAYLOR IMPACT TEST FOR A MICROPOROUS THERMOVISCOPLASTIC ROD

M. Lear and R. C. Batra

Department of Engineering Science and Mechanics, M/C 0219
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061, USA
rbatra@vt.edu, mlear@vt.edu

We analyze the initiation, development and propagation of cracks in axisymmetric, thermomechanical deformations of a circular metallic tungsten heavy alloy (WHA) rod impacting at normal incidence a smooth rigid flat target. The rod's material is modelled as strain hardening, strain -rate hardening and thermally softening. Gurson's flow potential as modified by Tvergaard and Needleman and the associated flow rule are used to model the viscoplastic response of the material. Both ductile and brittle fracture are studied. Ductile fracture is assumed to occur at a point if the porosity there reaches a material dependent critical value. Brittle fracture is assumed to occur at a point if the maximum principal tensile stress there reaches a material dependent critical value. Ductile and brittle fractures are assumed to propagate in the directions of the minimum porosity gradient and the minimum gradient of the maximum principal tensile stress respectively. At the newly formed crack surfaces, tractions are assumed to decay to zero slowly in order to minimize the effect of shock waves emanating from them.

The updated Lagrangian description of motion is used to describe thermomechanical deformations of the thermoviscoplastic bar and the effect of heat conduction is included. All of the plastic working is assumed to be converted into heating. A weak form of the balance laws is derived by the Galerkin approximation. The resulting coupled ordinary differential equations are integrated by using the subroutine LSODE. It adjusts the time step adaptively in order to compute the approximate solution within the prescribed accuracy.

The effect of the impact speed and the length/diameter ratio on the initiation, development and propagation of adiabatic shear bands and the resulting cracks is scrutinized.

Keywords: Impact, thermal softening, ductile fracture, brittle fracture, high strain rate.